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STAT [redacted] 6 February 1974

MEMORANDUM FOR: [redacted]

SUBJECT : Commerce Department request for Information on Level of Technology in the PRC Machine Tool Industry and in Semiconductor Crystal Processing

In response to the request made by Miss Jeanne Nelson, OEA/BEWT Commerce Department, for information on China's level of technology in the machine tool industry and in semiconductor crystal processing, I am attaching two brief reports. I prepared the report on semiconductor crystal processing. The machine tool report was prepared by [redacted]

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Industries Branch
China Division, OER

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Attachments:
As stated

[redacted]

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Level of Technology in the PRC Machine Tool Industry

General

1. During the period of Soviet aid China undertook the training of engineers and technicians in the processes for manufacturing machine tools (mt). Designing original machine tools is not as important in China as establishing production facilities to produce copies of imported mts and mastering the production processes, and, probably little effort was spent on educating designers.

2. Chinese machine tool plants typically alter the designs of foreign models in order to produce them with available Chinese production equipment. The result can be heavier castings for beds and frames, different gear ratios, redesigned spindle supports, etc. The basic geometric problems of chip removal by millers, planers, shapers, drills and lathes have not changed during the entire course of the industrial revolution. But, through evolutionary development of machine tool design, modern tools are faster, more accurate, easier to set up, cut harder materials, etc. than earlier models. The features of mts which made these advances possible are known to the Chinese and can be studied by them by examining imported tools. To introduce advanced features into their own product the Chinese need:

a. good grades of cast iron and other metals

b. precision equipment to machine precision mt parts

c. precision antifriction bearings.

3. At present China's immediate concern is to produce general purpose machine tools of greater precision, with which still more precise tools can be produced. The production of N.C. machine tools is of little importance to Chinese industry compared with obtaining greater precision in general purpose machine tools. The principal economic justification for NC tools is that they save labor. In China, labor savings will not offset the high first cost of NC machine tools. Nevertheless, it is expected that China will produce some prototypes of NC tools for familiarization, prestige and special applications. Such tools are not likely to show any improvement over the state-of-the-art elsewhere in the world.

4. In addition to striving for better general purpose tools, it is expected that China will produce special purpose tools for repetitive, high volume operations, such as making automotive parts. The quality of such tools will reflect the quality of general purpose tools, from which they derive their design and, in some cases, their parts.

5. It can be concluded from the foregoing that China has not mounted a major R and D effort in machine tools. The graduates of the nearly one hundred industrial schools that allegedly were trained to produce machine tools are likely to be engaged in solving practical problems of machine tool production -- from the drafting board where the foreign prototypes are redrawn to the shops where the sequences for machining the parts are determined and carried out.

6. The Chinese press officially asserts that the PRC needs NC machines for the aircraft industry and for other industry having to manufacture complex shapes with high precision. It is believed that the aircraft industry uses some NC machines of foreign origin. Labor saving is not an issue because labor cost has not become a problem in China where the average annual per capita income is less than $150.

7.. China has a rapidly growing machine building industry which requires large annual additions to its machine tool park. The machine tool industry is organized to produce simple general purpose tools and is trying to expand the output of such tools and at the same time to improve their accuracy, durability, and productivity. China's foreign trade program supports the machine tool industry by importing examples of modern free world machine tools for use as prototypes, and for specific applications not covered by the domestic product mix. China is also a major importer of precision antifriction bearings, which are not available in sufficient numbers to satisfy the needs of the machine tool industry.

8. The Chinese read the foreign technical press and are conversant with all developments in machine tool technology. They have acquired from free world firms a few NC machines (e.g., lathes, horozontal boring machines, milling machines, drilling machines, punch presses, and even some machining centers). In addition, they have imported NC parts such as pulse motors. The PRC has been engaged in a small way with

R and D on numerical control of machine tools since as long ago as 1958, when Tsing-hua University in Peking first attempted to put program control on a miller. Early programmed machines were described by knowledgeable Chinese as useless scrap iron. The first useable domestic prototypes were not available until 1965.

9. The construction of NC machines in China is believed to be carried on only in the laboratories of machine tool plants and technical universities, and mainly for familiarization purposes. Commercial-scale production is not thought to have started. It is believed that the Chinese would proudly publicize commercial scale production if they had achieved it. A very serious initial problem will be to provide the machine tool industry with technologically advanced components such as precision bearings for spindles, precision ball-screw assemblies, stepping motors and their controls, and numerical control equipment. There is even a basic need in the industry for many more general purpose tools of greater precision in order to achieve the precision required in parts for NC machine tools.

10. From time to time the Chinese press announces the manufacture of a prototype NC tool at one of its machine tool plants. The same individual tool is then exhibited at the next Canton Trade Fair. These tools are never available for export and are never demonstrated in a convincing way.

11. In April 1969, Ch'i-ch'i-ha-erh Machine Tool Plant No. 1 claimed to have achieved the prototype production of

China's first NC vertical lathe (model CK 5116) with punched tape input. It was essentially the Model C516A single column vertical lathe with programmed controls. In July 1970, the Peking Machine Tool Plant No. 1 claimed prototype production of the first Chinese NC four-coordinate milling machine (model XK5040). In November 1970, Peking Machine Tool Plant No. 3 claimed prototype production of the first six-coordinate milling and boring machine (Model SK 5325.6). Two other NC machines have been shown at Canton Trade Fairs. These were described as the TK 4145 digital NC jig borer with diffraction grating, and the XKF 515 program-controlled milling machine. None of these machines are thought to be in regular production.

12. The following NC machines were seen by a Commerce Department official in November 1973. Some of them were demonstrated.

At the Shanghai Industrial Exhibition

1. N/C Gear Shaper, Model YK5116 3-axis ptp
2. N/C, 8-station, turret type boring and milling machine, Model TK5525 3-axis ptp
3. N/C, 12-tool turret punch press, Model JK92-30, built by Shanghai Machine Tool Plant #2, ptp
4. N/C lathe, Model CK6140 newly developed by the Changhai Chungming Plant.

At the Chinese Export Commodities Fair-Kwangchow (Canton)

1. N/C line-cutting machine, Model SK.D 6730 used for cutting hardened steel tools and for cutting complicated shapes. Serial No. 003.

2. N/C vertical miller, Model XK5103 with simultaneous 3-axis operation by means of the KXZ 2132 controller. This machine has ball nut screw and hydraulic pulse motors for open loop control. X travel 800 mm; Y travel 500 mm; Z travel 250 mm; 4KW motor; 12 spindle speeds variable from 47 to 1500 rpm; wt. 4500kg. Developed by Tsinghua University workshops in Peking.

The KXZ 2132 controller can perform straight line, circular, and space interpolation and cutter radial compensation; uses 1" wide, 8-channel tape; tape reader speed, 200 characters/sec; max. radius of circular interpolation 10m; dead time (dwell) 200 msec; minimum resolution 0.01 mm/pulse.

Production of these machines is believed to be very small, probably in prototype amounts.

Level of Technology in PRC Crystal Processing

One of the principal technical problems faced by China in developing a capability for commercial-scale production of advanced types of semiconductors is the provision of large numbers of high-quality silicon monocrystals.* For fabrication into modern semiconductors such as epitaxial planar transistors and integrated circuits, the silicon monocrystals must be drawn by Czochralski furnaces and refined by float-zone furnaces.

China probably has a capability to make between 12 and 16 metric tons of monocrystals annually. This estimate includes both imported furnaces and domestically produced furnaces. China has imported a number of Czochralski and float-zone monocrystal production furnaces from Japan. These furnaces, which were imported between 1966 and 1969, provided China with its first industrial furnaces and served as models for future domestic production.

Production of domestic furnaces began in 1971 at a plant associated with the Institute of Mechanical Engineering in Peking. Furnaces produced at this plant, the Model 300 Czochralski crystal pulling furnace, are China's only production models. Output in 1973 was estimated at no more than 40 furnaces (see the table for description of Chinese crystal processing furnaces). The model 300 is a standard single chamber furnace but lacks the precision electronic controls

*Silicon monocrystals are used to represent simiconductor materials such as germanium and gallium arsinide. All are processed by the same equipment.

necessary to the consistent production of high-quality silicon monocrystals. Overall performance of the Model 300 is comparable to the crystal processing technology of the late 1950s. More recently, China has built three prototype versions of modern Czochralski furnaces. These prototypes incorporate automatic controls and are similar in performance to furnaces built in the West during the late 1960s. None are currently in production. China also has recently built its first domestic version of a float zone furnace. This prototype employs some state-of-the-art technology, but like other recently displayed prototypes is not yet in production.

Semiconductor materials processing furnaces currently in production are capable of producing high-quality monocrystals. However, because they lack precision controls and large handling capacities, commercial scale production of high-quality monocrystals is unlikely. Production of the new prototype furnaces, probably within the next several years, will still not ensure production of high quality monocrystals. China must concentrate on mastering the manufacturing technology which is required to effectively utilize such furnaces.

Table

PRC Crystal Processing Furnaces

Equipment	Model Number	Initial Year of Production or date Prototype Completed	Description
Monocrystal Pulling Furnace	300	1970	Production model. Czochralski pulling method. Employs synchronous motors for control of pulling operation. Pulls a single rod of monocrystalline material 2 inches in diameter. Prototype first built in 1968, production started in 1970.
Monocrystal Pulling Furnace	Unknown	1970	Prototype. Czochralski pulling method. Employs hydraulic system for control of pulling operation. Draws two rods of monocrystalline material. No evidence of production.
Monocrystal Pulling Furnace	Unknown	1971	Prototype. Czochralski pulling method. Employs hydraulic system for control of pulling operation. Draws three rods of monocrystalline material. No evidence of production.
Monocrystal Pulling Furnace	Unknown	1972	Prototype. Czochralski pulling method. Employs hydraulic system for control of pulling operation and proportion, integral, and differential (PID) action controllers are used to prevent vibration of the equipment. Main specifications are: feeding capacity, 1-2 kg; lifting speed of seed crystal axis, 0.5-5 millimeters/minute; and rotation speed of seed crystal axis, 10-100 revolutions per minute. Draws four rods of monocrystalline material. Probably intended for production.
Float Zone Crystal Furnace	QR-20-500	1972	Prototype. Employs silicon controlled rectifiers and high frequency induction heating. Capable of processing a single crystalline rod 1.5 inches in diameter and 20 inches in length. First float zone furnace produced in China.